

Nat. History vol. 3.

OUTLINES
OF
AGRICULTURE

ADDRESSED TO

SIR JOHN SINCLAIR, BART.

PRESIDENT

OF

THE BOARD OF AGRICULTURE.

BY A. HUNTER, M. D. F. R. S. L. & E.

“ It is the Earth that, like a kind Mother, receives us at our Birth, and sustains us when
“ Born. It is this alone, of all the Elements around us, that is never found an Enemy to Man.
“ The Body of Waters deluge him with Rains, oppress him with Hail, and drown him with
“ Inundations; the Air rushes in Storms, prepares the Tempest, or lights up the Volcano;
“ but the Earth, gentle and indulgent, ever subservient to the Wants of Man, spreads his Walks
“ with Flowers, and his Table with Plenty; returns, with Interest, every good committed to
“ her Care; and though she produces the poison, she still supplies the Antidote; though con-
“ stantly teased more to furnish the Luxuries of Man than his Necessities, yet even to the last
“ she continues her Indulgence, and when Life is over, she piously hides his remains in her
“ Bosom.”

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OUTLINE

AGRICULTURE

THE FIRST PART



THE SECOND PART

TO

SIR JOHN SINCLAIR, BART.

SIR,

THE Board of Agriculture owes its origin to your patriotic exertions, and as I have the honour of being a Member of that distinguished body, I consider myself as bound to depart a little from the line of my profession, in order to promote the views of an institution, which evidently has the general good of mankind for its object.

I am, Sir,

Your most obedient servant,

YORK, Jan. 1, 2
1795.

A. HUNTER.

OUTLINES OF AGRICULTURE.

THE Art of Husbandry boasts an origin coëval with the human race. Its age, however, seems to have contributed but little towards its advancement; being at present extended but a few degrees beyond its primitive institution.

Until the Philosopher condescends to direct the plough, Husbandry must remain in a torpid state. It is the peculiar happiness of this age, that men of a liberal education begin to cultivate this art with attention. The Board of Agriculture has already raised a spirit of emulation among our country gentlemen and sensible farmers. Each seems envious of contributing something towards the general stock of knowledge. Such a pleasing intercourse cannot fail of spreading the improvements in Agriculture over the most distant parts of this island.

I take upon me to say, that, to be a good husbandman, it is necessary to be a good chymist. Chymistry will teach him the best way to prepare nourishment for his respective crops; and to this circumstance the farmer ought diligently to attend, for it is well known that vegetables, as well as animals, have a disposition to prefer one kind of food to another.

It is also necessary for the husbandman to be a good mechanic, in order to be a judge of the instruments employed in dividing and loosening the soil; an operation of the greatest use to the farmer.

The ingenious Dr. Home has opened to our view a noble field for improvement. His reasoning is just, and conclusive; but it were to be wished that his experiments had been conducted upon a larger scale. However, contracted as they are, they will be found of great use to whoever intends to pursue the study of Agriculture upon rational principles.

In regard to what I shall observe on the nourishment of plants, it will be proper to say, that I have been directed in my researches by a strict attention to the analogy that subsists between animals and vegetables. We know that neither of them can subsist long without air and nourishment. Directed by instinct, the animal seeks its own

proper food; but the vegetable, not being possessed of the power of motion, must be satisfied with the nourishment that we give it.

I lay it down as a fundamental maxim, that all plants receive their principal nourishment from oily particles incorporated with water, by means of an alkaline salt or absorbent earth. Till oil is made miscible, it is unable to enter the radical vessels of vegetables; and, on that account, Providence has bountifully supplied all natural soils with chalky or other absorbent particles. I say natural soils, for those which have been assisted by art are full of materials for that purpose; such as lime, marl, soapashes, and the volatile alkaline salt of putrid dunghills.

It may be asked, whence do natural soils receive their oily particles? I answer, the air supplies them. During the summer months, the atmosphere is full of putrid exhalations, arising from the steam of dunghills, the perspiration of animals and smoke. Every shower brings down these oleaginous particles for the nourishment of vegetables.

Of these particles some fall into the sea, where they probably serve for the nourishment of fuci, and other submarine plants. They are, however, but seemingly lost, as the fish taken from the sea, and the weeds thrown upon

the beach, restore them again under a different form. Thus Providence, with the most consummate wisdom, keeps up the necessary rotation of things.

When they happen to fall upon a very sandy soil, the solar heat exhales the most of them. Hence an additional reason for covering our light soils with herbage during the summer months.

On the contrary, when they fall upon stiff land, or such as have been marled or limed, an intimate union is produced, too strong for the solar heat to exhale.

It is observed, that lime mechanically binds a hot sandy soil. We now see that it also fertilizes it; but the farmer must not presume too much upon that quality.

The ingenious Mr. Tull, and some others, contend that earth is the food of plants. If so, all soils equally tilled would prove equally prolific. The increased fertility of a well-pulverised soil, induced him to imagine that the plough could so minutely divide the particles of earth, as to fit them for entering into the roots of plants.

An open soil, if not too light in its own nature, will always produce plentiful crops. It readily receives the air, rains, and dews into its bosom, and at the same time gives the roots of plants a free passage in quest of food.

This is the true reason why land well tilled is so remarkably fruitful.

It is well known that animals take in many earthy particles by the mouth, but vegetables take in the fewest imaginable, having no way to discharge them. And indeed they hardly take in any, as is evident from the careful experiment made by Van Helmont, whereby it appears that a tree in the course of five years gained 164 pounds weight, while the earth in which it grew only lost two ounces.

Water is thought, by some, to be the food of vegetables, when in reality it is only the vehicle of nourishment. Water is an heterogeneous fluid, and is no where to be found pure. It always contains a solution of animal or vegetable substances. These constitute the nourishment of plants, and the element in which they are minutely suspended, acts only as a vehicle, in guiding them through the fine vessels of the vegetable body.

The hyacinth, and other bulbous roots, are known to perfect their flowers in pure water. Hence superficial observers have drawn an argument in favour of water being the food of vegetables. But the truth is, the roots, stem, and flowers of such plants are nourished by the mucilaginous juices of the bulb, diluted by the surrounding

ing water. This mucilage is just sufficient to perfect the flower—and no more. Such a bulb neither forms seeds, nor sends forth off-sets. At the end of the season, it appears weak, shrivelled, and exhausted, and is rendered unfit to produce flowers the succeeding year. A root of the same kind, that has been fed by the oily and mucilaginous juices of the earth, essentially differs in every particular. It has a plump appearance, is full of mucilage, with off-sets upon its sides.

All rich soils, in a state of nature, contain oil; and in those lands which have been under the plough for some years, it is found in proportion to the quantity of putrid dung that has been laid upon them, making allowance for the crops they have sustained.

To set this matter in a clearer light, let us attend to the effects of manures of an oily and mucilaginous nature, and we shall soon be satisfied that oil, however modified, is one of the chief things concerned in vegetation.

Rape-dust, when laid upon land, is a speedy and certain manure, though an expensive one, and will generally answer best on a limestone land, or where the soil has been moderately limed.

This species of manure is much esteemed by the farmer. It contains the food of plants ready prepared; but as it is

not capable of loosening the soil by any fermentation, the lands upon which it is laid ought to be in excellent tilth. At present, that useful article of husbandry is much diminished in goodness, owing to the improved methods of extracting the oil from the rape. Heat and pressure are employed in a double degree, and every other method is used to the prejudice of the farmer.

Farmers who live in the neighbourhood of large towns use abundance of foot. It is an oily manure, but different from the former, containing alkaline salt in its own nature, calculated as well for opening the soil, as for rendering the oily parts miscible with water.

It is observed that pigeons dung is a rich and hasty manure. These animals feed chiefly upon grains and oily feeds; it must therefore be expected that their dung should contain a large proportion of oil.

The dung of stable-kept horses is also a strong manure, and should not be used until it has undergone the *putrid ferment*, in order to mix and assimilate its oily, watery, and saline parts. Beans, oats, and hay, contain much oil. The dung of horses, that are kept upon green herbage, is of a weaker kind, containing much less oil. Swines' dung is of a saponaceous and oily nature, and perhaps is the richest of the animal manures. When made into a

compost, and applied with judgment, it is excellent both for arable and grass lands.

The dung of ruminant animals, as cows and sheep; is preferable to that of horses at grass, owing to the quantity of animal juices mixed with their food in chewing. And here I beg leave to remark in general, that the fatter the animal, *ceteris paribus*, the richer the dung.

Human ordure is full of oil and a volatile alkaline salt. By itself, it is too strong a manure for any land; it should therefore be made into a compost before it is used. The dung of carnivorous animals is plentifully stored with oil. Animals that feed upon seeds and grains come next, and after them follow those which subsist upon grass only.

To suit these different manures to their proper soils, requires the greatest judgment of the farmer; as what may be proper for one soil, may be highly detrimental to another.

In order to strengthen my argument in favour of oil being the principal food of plants, I must beg leave to observe, that all vegetables, whose seeds are of an oily nature, are found to be remarkable impoverishers of the soil, as hemp, rape, and flax; for which reason, the best manures for lands worn out by these crops, are such as

have a good deal of oil in their composition; but then they must be laid on with lime, chalk, marl, or soap-ashes, so as to render the oily particles miscible with water.

The book of Nature may be displayed, to shew that oily particles constitute the nourishment of plants in their embryo state. The oily feeds, as those of rape, hemp, line, and turnip, consist of two lobes, which, when spread upon the surface, form the feminal leaves. In them the whole oil of the seed is contained. The moisture of the atmosphere penetrates the cuticle of the leaves, and, mixing with the oil, constitutes an emulsion for the nourishment of the infant plant. The oleaginous liquor being consumed, the feminal leaves decay, having performed the office of a mother to her tender infant. To persons unacquainted with the analogy between plants and animals, this reflection will appear strange. Nothing, however, is more demonstrable.

Fig. 3. shews the seed-leaves, or placenta, of a turnip, with its radicle and germ. *a.* The germ. *b.* The placenta, or seed-leaves. *c.* The radicle.

On the contrary, wheat, oats, pease, beans, barley, and rye, keep their placenta, or feminal leaves, within the earth; in which situation they supply the tender germ

with oily nutriment, until its roots are grown sufficiently strong to perform the office required of them.

It is usual to talk of the salts of the earth; but chymistry has not been able to discover any salts in land which has not been manured, though oil may be readily obtained from every soil, the very sandy ones excepted.

Marl, though a rich manure, has no salts. It is thought to contain a small portion of oleaginous matter, and an absorbent earth, of a nature similar to limestone, with a large quantity of clay intermixed.

Lime mixed with clay comes nearest to the nature of marl of any factitious body that we know of, and may be used as such, where it can be had without much expence. But as lime used in this manner soon recovers the air of which it was deprived during calcination, I would advise unburnt limestone to be mixed with the clay, which will reduce the expence to little more than digging the materials. If a small portion of sand be added to this composition, it will form a body perfectly similar to marl.

It is the opinion of some, that lime enriches the land it is laid upon, by means of supplying a salt fit for the nourishment of plants; but by all the experiments that

have been made upon lime, it is found to contain no kind of salt. Its operation therefore should be considered in a different light. By the fermentation that it induces, the earth is opened and divided, and, by its absorbent and alkaline quality, it unites the oily and watery parts of the soil.

From viewing lime in this light, it is probable that it tends to rob the soil of its oily particles, and in time will render it barren, unless we take care to support it with rotten dung, or other manures of an oily nature.

As light sandy soils contain but a small proportion of oleaginous particles, we should be extremely cautious not to overdo them with lime; unless we can at the same time assist them liberally with rotten dung, woollen rags, shavings of horn, or other manures of an animal kind. Its great excellence, however, upon a sandy soil, is by mechanically binding the loose particles, and thereby preventing the liquid parts of the manure from escaping out of the reach of the radical fibres of the plants.

Upon clay the effect of lime is different; for by means of the gentle fermentation that it produces, the unsubsided soil is opened and divided: the manures laid on readily come into contact with every part of it; and the fibres of the plants have full liberty to spread themselves.

It is generally said that lime answers better upon sand than upon clay. This observation will undoubtedly hold good as long as the farmer continues to lime his clay lands in a scanty manner. Let him double the quantity, and he will then be convinced that lime is better for clay than sand. It may be justly answered, that the profits will not admit of the expence. I agree. But then it must be understood that it is the application, and not the nature of the lime, that should be called in question. Clay, well limed, will fall in water, and ferment with acids. Its very nature is changed. However, let the farmer who uses much lime for his clay lands, be instructed to manure them well, otherwise the soil will become too hard to permit the roots of the plants to spread themselves in search of food. In consequence of the fermentation raised in the soil, the fixed air is set at liberty, and in that state of activity it becomes an useful instrument in dividing the tenaceous clay. To lands so circumstanced, the air, rains, and dews, are freely admitted, and the soil is enabled to retain the nourishment that each of them brings.

It is the nature of lime to attract oils and dissolve vegetable bodies. Upon these principles we may account for the wonderful effects of lime in the improvement of black moor-land. Moor-earth consists of dissolved, and half-

dissolved, vegetable substances. It is full of oil. Lime dissolves the one and assimilates the other.

Such lands, not originally worth fourpence *per* acre, may be made, by paring, burning, and liming, to produce plentiful crops of turnips, which may be followed with oats, barley, or rye, according to the inclination of the owner.

To the universal principle, oil, we must add another of great efficacy, though very little understood; I mean the nitrous acid of the air.

That the air does contain the rudiments of nitre, is demonstrable from the manner of making saltpetre in the different parts of the world. The air contains no such salt as perfect nitre; it is a factitious salt, and is made by the nitrous acid falling upon a proper matrix. The makers of nitre form that matrix of the rubbish of old houses, fat earth, and any fixed alkaline salt. The universal acid, as it is called, is attracted by these materials, and forms true nitre, which is rendered pure by means of crystallization, and in that form it is brought to us. In very hot countries the natural earth forms a matrix for nitre, which makes the operation very short.

It is observed that nitre is most plentifully formed in winter, when the wind is northerly: hence we may understand the true reason why land is fertilized by being laid up in high ridges during the winter months. The good effects of that operation are wholly attributed to the mechanical action of the frost upon the ground. Light soils, as well as the tough ones, may be exposed in high ridges, but with some limitation, in order to imitate the mud walls of Germany, which are found, by experience, to collect considerable quantities of nitre during the winter.

After saying so much in praise of nitre, it will be expected that I should produce some proofs of its efficacy, when used as a manure. I must confess that experiments do not give us any such proofs. I shall therefore consider this nitrous acid, or, as some philosophers call it, the *acidum vagum*, in the light of a vivifying principle, with whose operation we are not yet fully acquainted.

I have already observed, that there subsists a strong analogy between plants and animals. Oil and water seem to make up the nourishment of both. Earth enters very little into the composition of either. It is known, that animals take in a great many earthy particles at the mouth, but they are soon discharged by urine and stool. Vegetables take in the smallest portion imaginable of

earth; and the reason is, they have no way to discharge it.

It is highly probable, that the radical fibres of plants take up their nourishment from the earth, in the same manner that the lacteal vessels absorb the nutriment from the intestines; and as the oily and watery parts of our food are perfectly united into a milky liquor, by means of the spittle, pancreatic juice, and bile, before they enter the lacteals, we have all the reason imaginable to keep up the analogy, and suppose that the oleaginous and watery parts of the soil are also incorporated, previous to their being taken up by the absorbing vessels of the plant.

To form a perfect judgment of this, we must reflect that every soil, in a state of nature, has in itself a quantity of absorbent earth, sufficient to incorporate its inherent oil and water; but when we load it with fat manures, (as in the case of old Kitchen Gardens) it becomes essentially necessary to bestow upon it, at the same time, something to assimilate the parts. Lime, soap-ashes, kelp, marl, and all the alkaline substances, perform that office.

In order to render this operation visible to the senses:— Dissolve one drachm of Russia pot-ash in two ounces of water; then add two spoonfuls of oil. Shake the mixture, and it will instantly become an uniform mass of a

whitish colour, adapted to all the purposes of vegetation.

This easy and familiar experiment is a just representation of what happens after the operation of burn-baking, and consequently may be considered as a confirmation of the hypothesis advanced.—Let us attend to the process.

The sward being reduced to ashes, a fixed alkaline salt is produced. The moisture of the atmosphere soon reduces that salt into a fluid state, which, mixing with the soil, brings about an union of the oily and watery parts, in the manner demonstrated by the experiment.

When the under stratum consists of a rich vegetable mould, the effects of burn-baking will be lasting. But when the soil happens to be thin and poor, the first crop frequently suffers before it arrives at maturity.

The farmer therefore, who is at the expence of paring and burning a poor soil, should bestow upon it a portion of rotten dung, or shambles manure, before the ashes are spread, in order to supply the deficiency of oily particles, and he should afterwards keep it in vigour by bestowing upon it a reasonable portion of manure, otherwise the paring and burning such a soil, will, in the end, prove a ruinous practice. On the contrary, when a

judicious course of crops is instituted, and well supported, the practice may be considered as beneficial. However, such a kind of land should on no account be kept long under the plough, but be laid down to grass, after a few crops, judiciously chosen, are taken from it. When it is intended to break up meadow-land that is over-run with rushes, coarse grass, and tap-rooted weeds, it is a good practice to pare and burn the surface, taking off a thick turf. This, after a proper drainage, is the best method of bringing coarse meadow-land into cultivation; and I apprehend it will not be objected to by those land-owners who consider burn-baking as a ruinous practice.

Hitherto I have considered plants as nourished by their roots. I shall now take a view of them as nourished by their leaves. An attention to this part of the vegetable system is essentially necessary to the rational farmer.

Vegetables that have a succulent leaf, such as vetches, pease, beans, and buck-wheat, draw a great part of their nourishment from the air, and on that account impoverish the soil less than wheat, oats, barley, or rye, the leaves of which are of a firmer texture.

Rape and hemp are oil-bearing plants, and, consequently, impoverishers of the soil; but the former less so

than the latter, owing to the greater succulency of its leaf.

The leaves of all kinds of grain are succulent for a time; during which period the plants take little from the earth; but as soon as the ear begins to be formed, they lose their softness, and diminish in their attractive power.

The radical fibres are then more vigorously employed in extracting the oily particles of the earth, for the nourishment of the seed.

It is not sufficient for the farmer to be acquainted with the nature of the different manures and soils. He should also know the shape of the roots of such plants as are used in field-husbandry. The soil and roots are so intimately connected, that the knowledge of both becomes essential.

Wheat has two sets of roots. The first comes immediately from the grain; the other shoots from the crown some time after. I shall distinguish them by *feminal* and *coronal* roots.

Plants, according to their species, observe a regular uniformity in the manner of spreading their roots; for which reason the same grain cannot be continued long

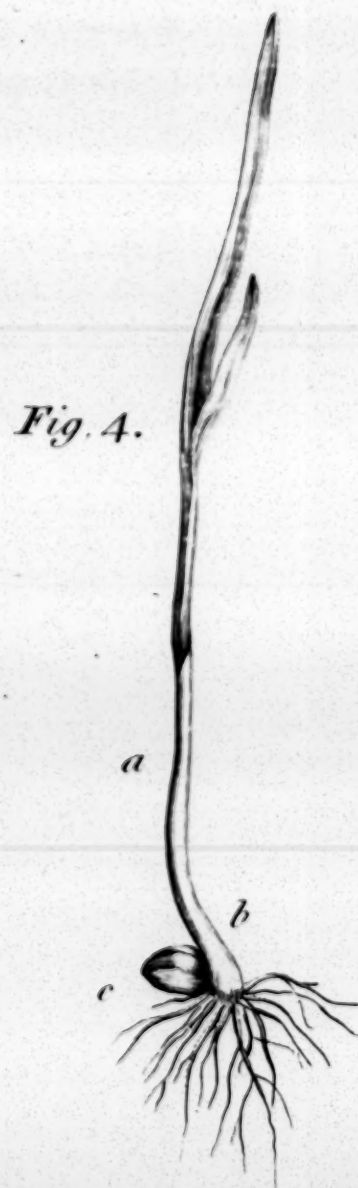
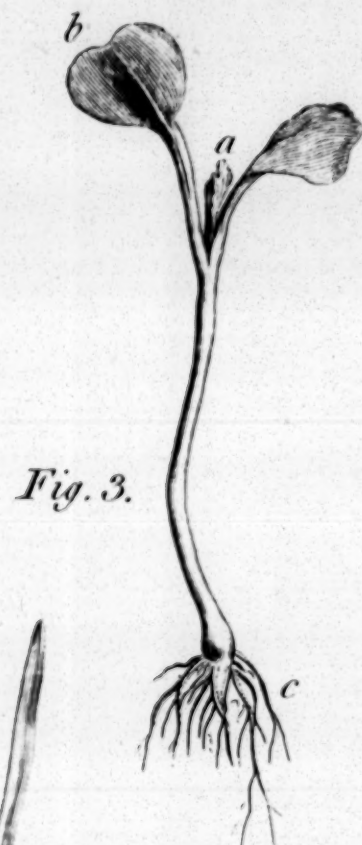
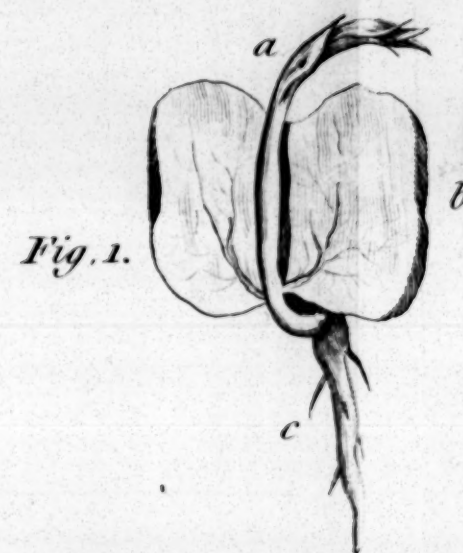
upon the same soil. It is not that each takes from the earth such particles as are congenial: The food of all plants is the same; only some require more, some less. Some take it near the surface, others seek it deeper. A careful inspection of a healthy root will at once demonstrate the bias of nature. An examination of the soil will shew how far they will agree. This is the rational basis of the change of species, so well understood in Norfolk, where tap-rooted plants always follow those that root superficially.

To be convinced that we reason improperly when we say, that every plant takes from the earth such particles as are natural to it, we have only to consider, that a lemon, engrafted upon an orange stock, is capable of changing the sap of the orange into its own nature, by a different arrangement of the nutritive juices; and daily observation teaches us that the grass of the field is capable of being changed into flesh and bone; but how this transmutation is performed, remains, and perhaps ever will remain, unknown. The same mass of earth, by a certain arrangement of its parts, can give life and vigour to the bitter aloe, and to the sweet cane; to the cool house-leek, and to the fiery mustard; to the nourishing grains, and to the deadly nightshade. We may eat the earth, and drink the water that moistens it, and yet, by a wonderful modification of its parts, it is made to produce both

bread and poison. All nature is in motion; and, perhaps, there is not a particle of matter that is absolutely at rest, being employed either in acts of combination or dissolution; two great operations of nature that follow each other in endless succession.

To return. Wheat being subject to the severity of winter, its roots are wonderfully disposed to withstand the inclemency of the season. A view of their shape will direct us in the manner of sowing that grain to the most advantage; and at the same time enable us to account for some of the phænomena observable in the growth of it.

I have observed that wheat has a double root. The first, or *feminal* root, is pushed out at the same time with the germ, which, together with the *farina*, nourishes the plant during the winter before the crown and coronal roots are formed. Fig. 4. represents a plant of wheat at this early season, when it has only got its feminal root. *a.* The part from whence the coronal root springs. *b.* The pipe of communication between the first root and the crown, which, in this early stage of the plant is covered with a membranous sheath. *c.* The grain with its feminal root. At this season the grain is filled with a milky juice for the support of the plant, during what may be called its infant state.



In the spring, when the crown has become sufficiently large, it detaches a number of strong fibres which push themselves obliquely downwards. These are the coronal roots, serving to nourish the plant till it arrives at maturity. A small pipe preserves the communication between them and the feminal roots. This makes an essential part of the plant, and is observed to be longer or shorter, according to the depth that the seed has been buried. It is remarkable, however, that the crown is always formed just within the surface. Its place is the same whether the grain has been sown deep or superficial. I believe I do not err when I call this *vegetable instinct*. As the increase of wheat depends upon the vigorous absorption of the coronal roots, it is no wonder that they should fix themselves so near the surface, where the soil is always the richest. From an attention to this circumstance, we are led to explain the operation of top-dressings. Fig. 2. represents a grain of wheat sown at a proper depth. *a.* The crown with its roots. *b.* The pipe of communication. *c.* The feminal roots, with the capsule of the grain. Fig. 5. shews a plant of wheat sown superficially. *a.* The crown and roots. *b.* The feminal roots. *c.* The capsule of the grain. Hence it is obvious that wheat, sown superficially, must be exposed to the severity of the frost from the shortness of the pipe of communication. The plant, in that situation, has little benefit from its feminal root. On the contrary, when the

grain has been properly covered, the seminal and coronal roots are kept at a reasonable distance. The crown being well nourished by means of the seminal root during the winter, sends up numerous stalks in the spring. On the tillering of the corn the goodness of the crop principally depends. A field of wheat sown by the drill plough, always makes a better appearance than one sown by the harrows. In the first, the length of the pipe of communication is regularly the same; but in the other, it is irregular, being either too long or too short. From these anatomical facts we are led to reason justly upon the application of manures. Till the farmer can scientifically explain the manner that the different kinds of plants feed themselves, it will be impossible for him to reduce his profession to the standard of reason. Most farmers are acquainted with the nature and application of heavy manures, but in general they are ignorant of the nature and application of those that are light, and which pass under the name of top-dressings.

In the northern counties wheat is generally sown late. When the frosts come, the seminal roots that are near the surface, are frequently chilled, so that they can but imperfectly supply the plant with nourishment during the winter. This inconvenience, however, may easily be prevented by burying the seed deeper, or in other words, by lengthening the pipe of communication.

It will here be necessary to remark, that as top-dressings can only operate a little way within the surface, they are therefore only proper for horizontal feeders, as wheat, oats, barley, and rye. Beans and tap-rooted plants require such heavy manures as are worked into the land by the action of the plough.

It may be objected, that turnips, though tap-rooted, yet receive benefit from top-dressings; but it must be considered that they operate upon the plant by hastily pushing it into rough leaf, thereby securing it against the fly. After this the turnip flourishes or declines in proportion to the richness or poverty of the soil.

Soot, malt dust, pigeons' dung, and rape dust, are considered as top-dressings. They are consequently never worked into the land by the plough. In that they essentially differ from other manures. When any kind of manure is worked into the land by the plough, we mean to lighten the soil; but when we apply top-dressings, we only consider the nourishment of the plants, having no regard to loosening the earth. Light, sandy, and limestone lands are best managed by top-dressings. Stiff loams and clays require lime and rotten dung to break the cohesion of their parts. The last remains in the ground for the benefit of the succeeding crops; the other is only the food of the year. The tillage farmer, whose soil is thin,

should pay a careful attention to top-dressings. They are the soul of his husbandry.

On the limestone lands in Yorkshire, rape dust is chiefly used; but the price is now so much advanced, that the farmer can scarcely afford to purchase it. An acre of wheat land cannot be dressed with less than three quarters of rape dust; four quarters are required for an acre of barley. The price is about 19s. per quarter.

In Flanders, where top-dressings are well understood, they dry and powder human ordure, which they use as a top-dressing, and find it of a rich quality. In large manufactories, and in places where a number of people live together, it may be a judicious practice to receive all excrementitious matters upon saw-dust, which, after being frequently turned over, may be converted into one of the richest dressings, with the advantage of being obtained at a small price. Where saw-dust cannot be procured, coal-ashes and earth will answer the purpose equally well.

The farmer should lose no opportunity to increase his quantity of manure. He should be told that even a snail, however diminutive, adds something, both to the size and richness of his dunghill. The public sewers of all towns, instead of emptying themselves into rivers, should be directed into reservoirs filled with earth and small rubbish;

a contrivance that would produce an accumulation of heavy manure at a small expence.

Having in several parts of these Outlines hinted at the analogy that subsists between plants and animals, I am induced to think that an extension of that beautiful subject will not be thought foreign to the object of this discourse.

It is an established truth, that vegetables are placed in a middle degree between animals and minerals. They are superior to minerals, in having organized parts; but inferior to animals, in being destitute of sensation.

As they are fixed to a place, they have few offices to perform. An increase of body and maturation of their seed, seem all that is required of them. For these purposes Providence has wisely bestowed upon them organs of a wonderful mechanism. The anatomical investigation of these organs, is the only rational method of arriving at any certainty concerning the laws of the vegetable œconomy. Upon this subject Dr. Hales judiciously observes, "that as the growth and preservation of vegetable life is promoted and maintained, as in animals, by the very plentiful and regular motion of their fluids, which are the vehicles ordained by nature to carry nutriment to every part, it is therefore reasonable to hope

“that in them also, by the same method of inquiry, considerable discoveries may in time be made, there being, in many respects, a great analogy between plants and animals.”

From this analogy, many eminent naturalists have been led to suppose a regular circulation of the vegetable juices. M. Perrault, M. Major, M. Marriotte, Malpighi, and Dr. Grew, contended, much about the same time, for the circulation of the sap. According to their microscopical observations, the wood of trees, and the flesh of plants, consist of fine capillary tubes, which run parallel from the root, through the trunk and branches. These they looked upon as arteries. Other minute vessels were observed running between the wood and inner bark, which they distinguished by the name of veins. They also described, very correctly, the tracheæ, or air-vessels, which take their course through the fibres of the wood. These anatomical preliminaries being settled, they proceeded to reason in this manner:

The root having absorbed a quantity of nourishment from the earth, it is made to ascend through the vessels of the wood, by the alternate expansion and contraction of the tracheæ, assisted by the natural absorption of the sap-vessels themselves. They supposed the sap to be rarified to the degree of a fine vapour, in which state it

mounted upward to the extreme parts of the plant, where, meeting with the external air, it became condensed into a liquor, and in that form returned to the root by the venal system, between the wood and bark. Dr. Hales set aside this doctrine, and, in the most satisfactory manner, made it appear that the vegetable juices rise and fall in the same series of vessels, and consequently have no circulation.

It is remarkable that Dr. Hervey should have been the first who established the *circulation* of the blood, in opposition to most of the anatomists of Europe; and that Dr. Hales should have disproved the *circulation* of the vegetable juices, contrary to the opinion of every naturalist of his time.

The seed of a plant, after it has dropt from the ovary, may be considered as an impregnated ovum, within which the embryo plant is securely lodged. In a few days after it has been committed to the earth, we may discern the rudiments of the future plant. Every part appears to exist in miniature. The nutritive juices of the soil insinuate themselves between the original particles of the plant, and bring about an extension of its parts. This is what is called the growth of the vegetable body.

Every one knows that animals, instead of being strengthened, are enfeebled by a supply of improper nourishment. It is the same thing with regard to vegetables; but with this difference, that animals refuse whatever is improper, while vegetables, from their passive nature, must be content with what we give them.

The impregnated ovum of every animal, after it has passed down the Fallopian tube, and fixed itself to the bottom of the uterus, is found to contain the tender embryo within two membranes called Chorion and Amnion. In this situation the embryo could not long subsist without a supply of nourishment. Nature has therefore bestowed upon it a placenta and umbilical chord, through which the blood of the mother is transmitted, for its preservation and increase.

Seeds are disposed, by Providence, nearly in the same manner. They have two coverings, answering to the Chorion and Amnion, and two lobes which perform the office of the placenta. These lobes constitute the body of the seed, and, in the farinaceous kinds, they are the flour of the grain. Innumerable small vessels run through the substance of the lobes, which, uniting as they approach the feminal plant, form a small chord to be inserted into the body of the germ. Through it the nutri-

ment supplied by the placenta, or lobes, is conveyed for the preservation and increase of the embryo plant.

In order that I may be clearly understood, it will be necessary to observe, that the lobes of farinaceous grains are fixed in the earth. They are therefore improperly termed feminal leaves, being rather the placenta, or cotyledons of the plant. On the contrary, vegetables that have an oily feed, as rape, hemp, line, and turnip, carry their lobes upward, and spread them upon the surface, in the form of broad leaves. These, though they perform the office of a placenta, are properly feminal leaves.

Fig. 1. represents the body, or placenta, of a bean, with its germ, radicle, and umbilical ramifications.—*a*. The germ.—*b*. The body, or placenta, with the umbilical ramifications.—*c*. The radicle.

Fig. 3. represents the placenta, or seed-leaves, of a turnip, with its radicle and germ.—*a*. The germ.—*b*. The placenta, or seed-leaves.—*c*. The radicle.

To illustrate the subject of vegetation, let us take a view of what happens to a bean, after it has been committed to the earth.

In few days, sooner or later, according to the temperature of the weather and disposition of the soil, the ex-

ternal coverings open at one end, and disclose to the naked eye part of the placenta, or body of the grain. This substance consists of two lobes, between which the seminal plant is securely lodged. Soon after the opening of the membranes, a sharp-pointed body appears: This is the root. By a kind of principle, which seems to carry with it some appearance of instinct, it seeks a passage downwards, and fixes itself into the soil. At this period the root is a smooth and polished body, and perhaps has but little power to absorb any thing from the earth, for the nutriment of the germ.

The two lobes now begin to separate, and the germ, with its leaves, may plainly be discovered. As the germ increases in size, the lobes are further separated, and the tender leaves being closely joined, push themselves forward in the shape of a wedge.

These leaves take a contrary direction to the root. Influenced by the same miraculous instinct, if I may be allowed the expression, they seek a passage upward; which having obtained, they lay aside their wedge-like form, and spread themselves in a horizontal direction, as being the best adapted for receiving the rains and dews.

The radicle, every hour increasing in size and vigour, pushes itself deeper into the earth, from which it now draws some nutritive particles. At the same time the leaves of

the germ, being of a succulent nature, assist the plant, by attracting from the atmosphere such particles as their tender vessels are fit to convey. These particles, however, are of a watery kind, and have not, in their own nature, a sufficiency of nutriment for the increasing plant.

Vegetables and animals, during their tender states, require a large share of balmy nourishment. As soon as an animal is brought into life, the milk of its mother is supplied in a liberal stream, while the tender germ seems only to have the crude and watery juices of the earth for its support. In that, however, we are deceived. The Author of nature, with equal eye, watches over the infancy of all his works. The animal enjoys the milky humour of its parent. The vegetable lives upon a similar fluid, though differently supplied. For its use the farinaceous lobes are melted down into a milky juice, which, as long as it lasts, is conveyed to the tender plant by means of innumerable small vessels, which are spread through the substance of the lobes. These vessels, uniting into one common trunk, enter the body of the germ, and perform the office of an umbilical chord. Without this supply of balmy liquor, the plant must inevitably have perished, its root being then too small to absorb a sufficiency of food, and its body too weak to assimilate it into nourishment.

Turnips, and all the tribe of Brassicas, in opposition to most of the farinaceous vegetables, spread their feminal leaves upon the surface. These leaves contain all the oil of the seed, which, when diluted by the moisture of the atmosphere, forms an emulsion of the most nourishing quality. How similar is this juice to the milk of animals! On account of its sweetness, the feminal leaves are greedily devoured by the fly. This demonstrably proves that oil constitutes the nourishment of plants in their tender state.

A grain of wheat, as soon as the germ has made its appearance, shews the milky liquor to the naked eye; but as the plant increases in size, the balmy juice diminishes, till at last it is quite exhausted. The umbilical vessels then dry up, and the external covering of the grain appears connected to the root in the form of a shrivelled bag.

Here is no mortality. From the moment that the seed is lodged in its parent earth, the vegetative soul begins its operations, and, in one continued miracle, proves the wisdom and bounty of an Almighty Providence!

It is worthy of observation, that farinaceous vegetables and oviparous animals are nourished, in their tender states, nearly in the same manner.

We have already seen that the embryo plant is supported by the farina melted down into a milky liquor,

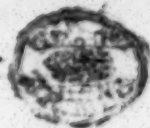
and conveyed into its body by means of umbilical vessels, at a time when the radicle was unable to supply a sufficiency of nutriment.

An oviparous animal, from the time that it is brought into light, seems to receive all its nourishment from without. This, however, is only an appearance. The yolk of the egg, remaining entire during incubation, is received into the body of the animal, and in a manner similar to the passage of the milky juice of the vegetable, is slowly conveyed into the vessels of the tender chick. Thus a sweet nourishment is prepared at a time when neither the industry of the animal, nor the attention of its mother, could have procured a sufficient supply.

It is wonderful to observe the attention of Providence to the infancy of vegetable life! but our wonder is turned into adoration when we observe the same goodness bestowed upon every part of animated nature: and, to establish this important truth, we have only to take a view of the state of an egg on the fourth day of incubation. Fig. 1. represents the containing and contained parts of an egg, as they appear on the removal of the fore-part of the shell. Fig. 2. The shell. Fig. 3. The membranes which line the inside of the shell, and inclose the whole contents. *a.* The shell. *b.* The cavity formed by the membranes, in which a small portion of air is lodged.

c. The inner membrane. Fig. 4. The white which serves for the nourishment of the chick during incubation. Fig. 5. The yolk, with the speck of life which is analogous to the vegetable germ. *a.* The yolk. *b.* The cicatricula, containing the speck of life. *c. c.* The chalazæ, or twisted extremities of the membrane that surrounds the yolk. Now, if we compare these chalazæ to the extremities of an axis passing through the yolk, we shall find that sphere composed of two unequal portions, its axis not passing exactly through its centre. And as the cicatricula, with the speck of life, is always placed on the side of the smaller portion, it follows that, in all the positions of the egg, during the first six days of incubation, it must be uppermost, and consequently nearest the hen; for the yolk is a body specifically heavier than the white with which it is surrounded.

How beautiful are the general laws of Providence! The more we explore them, the more we have cause for wonder and astonishment. Every thing is wisely disposed; nothing is fortuitous; all is order, regularity, and wisdom.



A. HUNTER.

Fig. I.

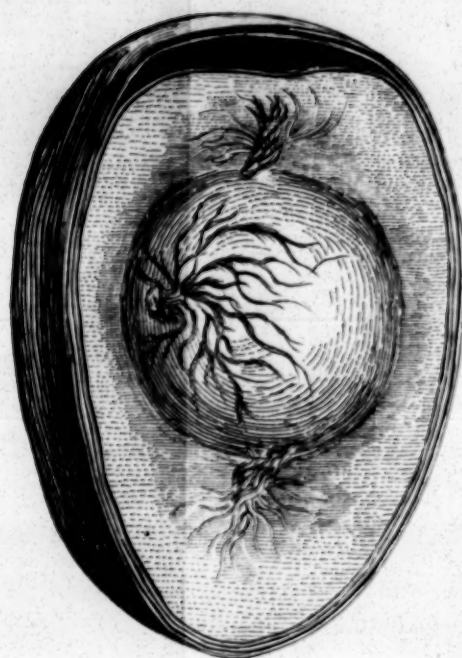


Fig. II.

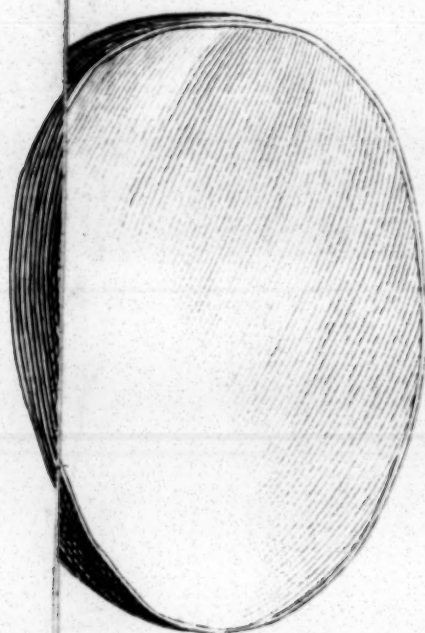


Fig. III.



Fig. IV.

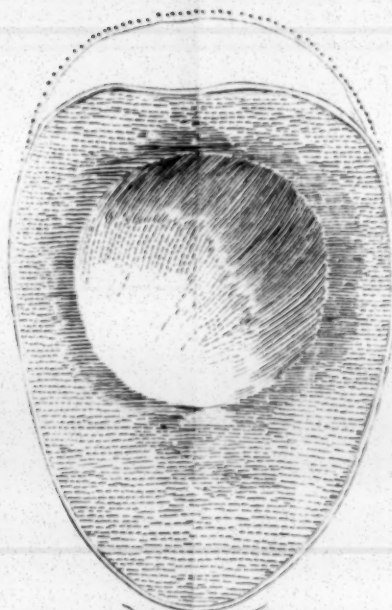
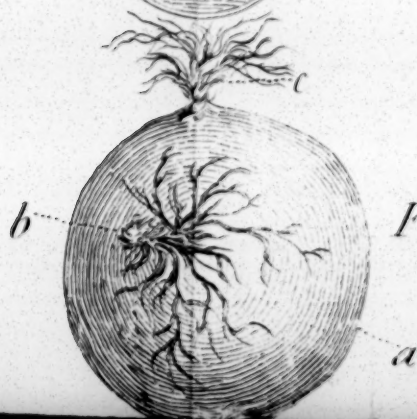


Fig. V.





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AS the profits arising from the sale of this Publication are to be occasionally applied in clothing a few poor Lunatics, Ladies and Gentlemen who are disposed to give a small sum towards that benevolent purpose, may transmit it to Doctor Hunter, Physician to the Lunatic Asylum, at York.



